

# PSYCHOLOGY 305

# COGNITIVE PROCESSES

## *Agenda*

- Quiz
- Object Recognition (Chap 6, excluding p241~245)

## *Announcements*

- Short paper due 9/23

# Short Paper

- Relate a cognitive process we have discussed to some aspect of society
  - Education, economics, politics, sports, etc.
- Maximum of 2 pages double spaced
- Grading:
  - Correct summary of the cognitive process
  - Link to aspect of society
  - Writing skill

# What Is Object Recognition?

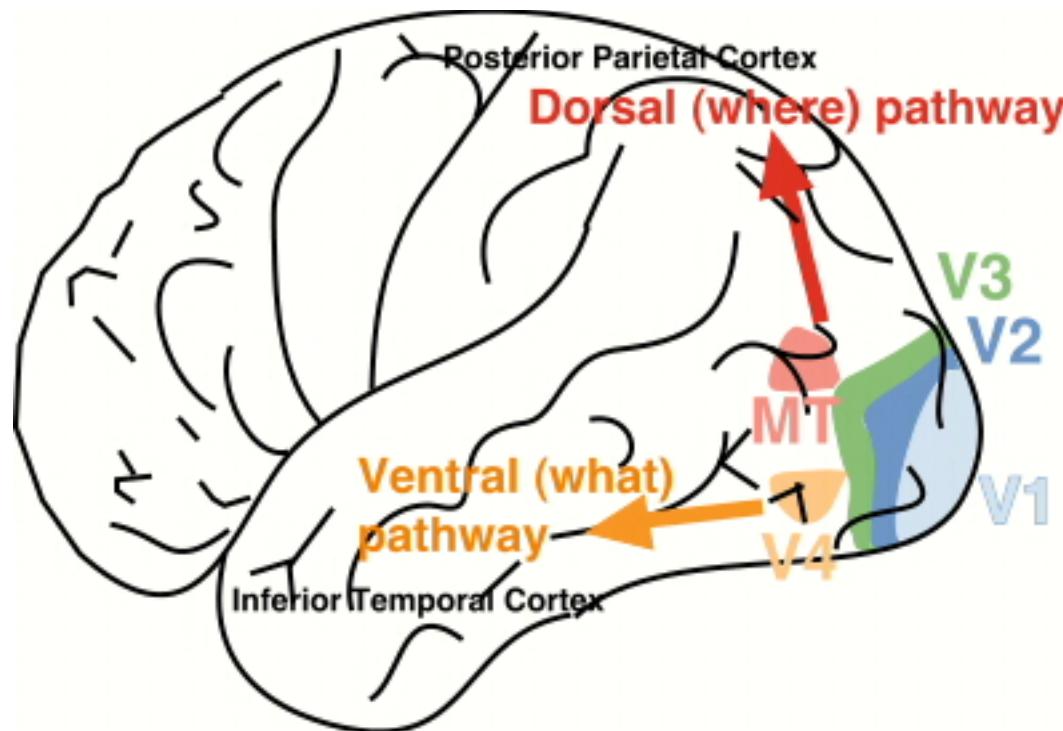
## Why Do We need It?



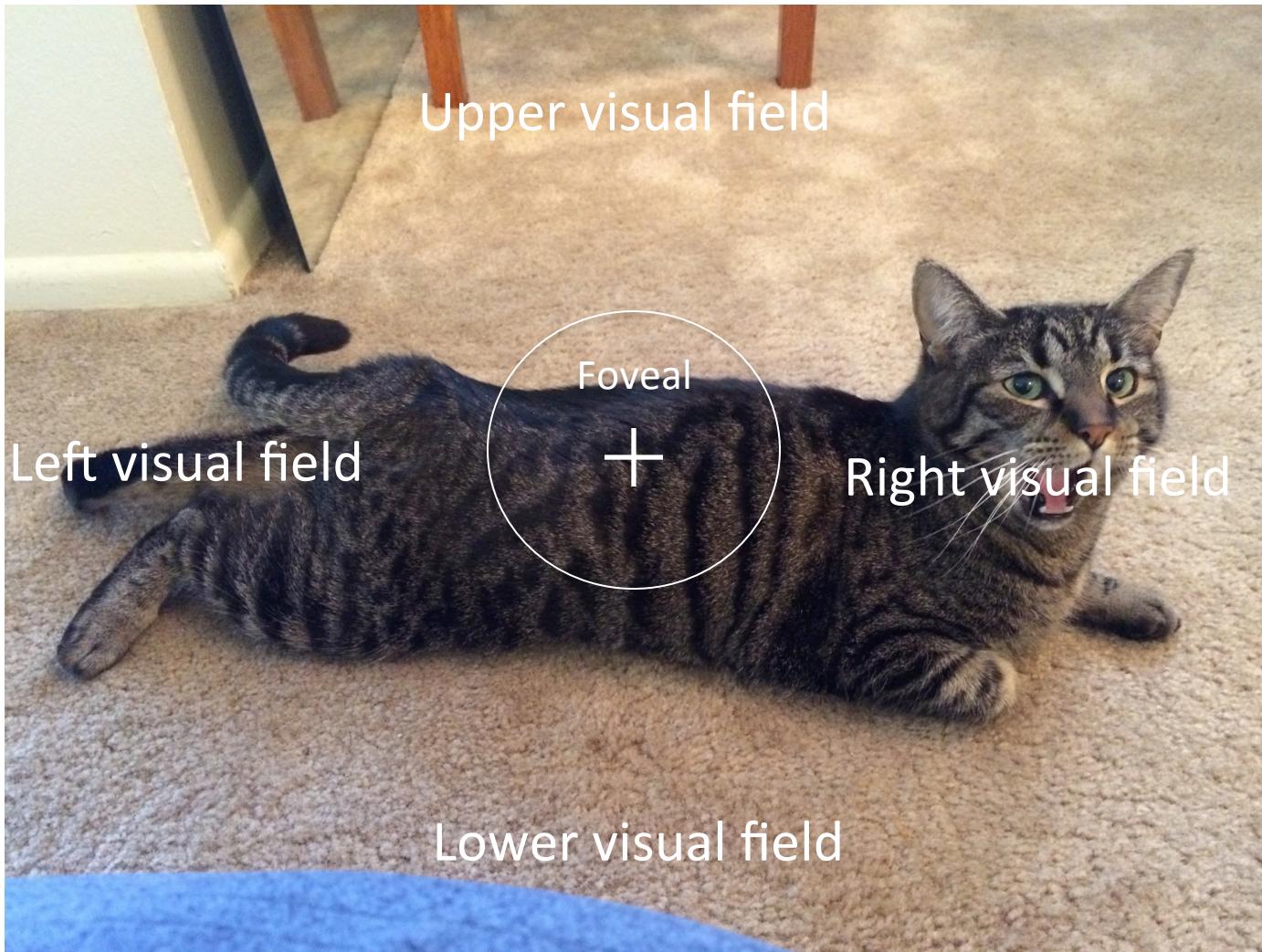
*"You look just like your profile picture."*

# Two Pathways: Anatomical Evidence

Two major fiber tracts that come out of occipital areas

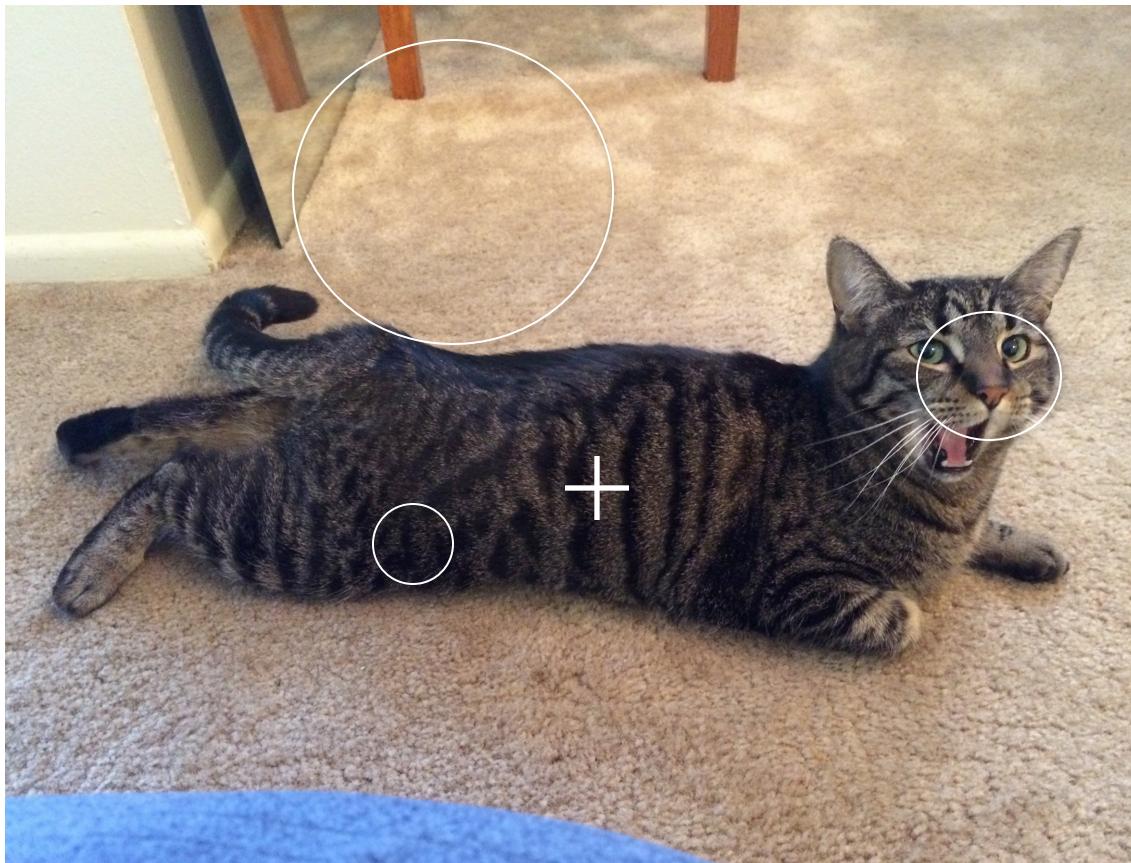


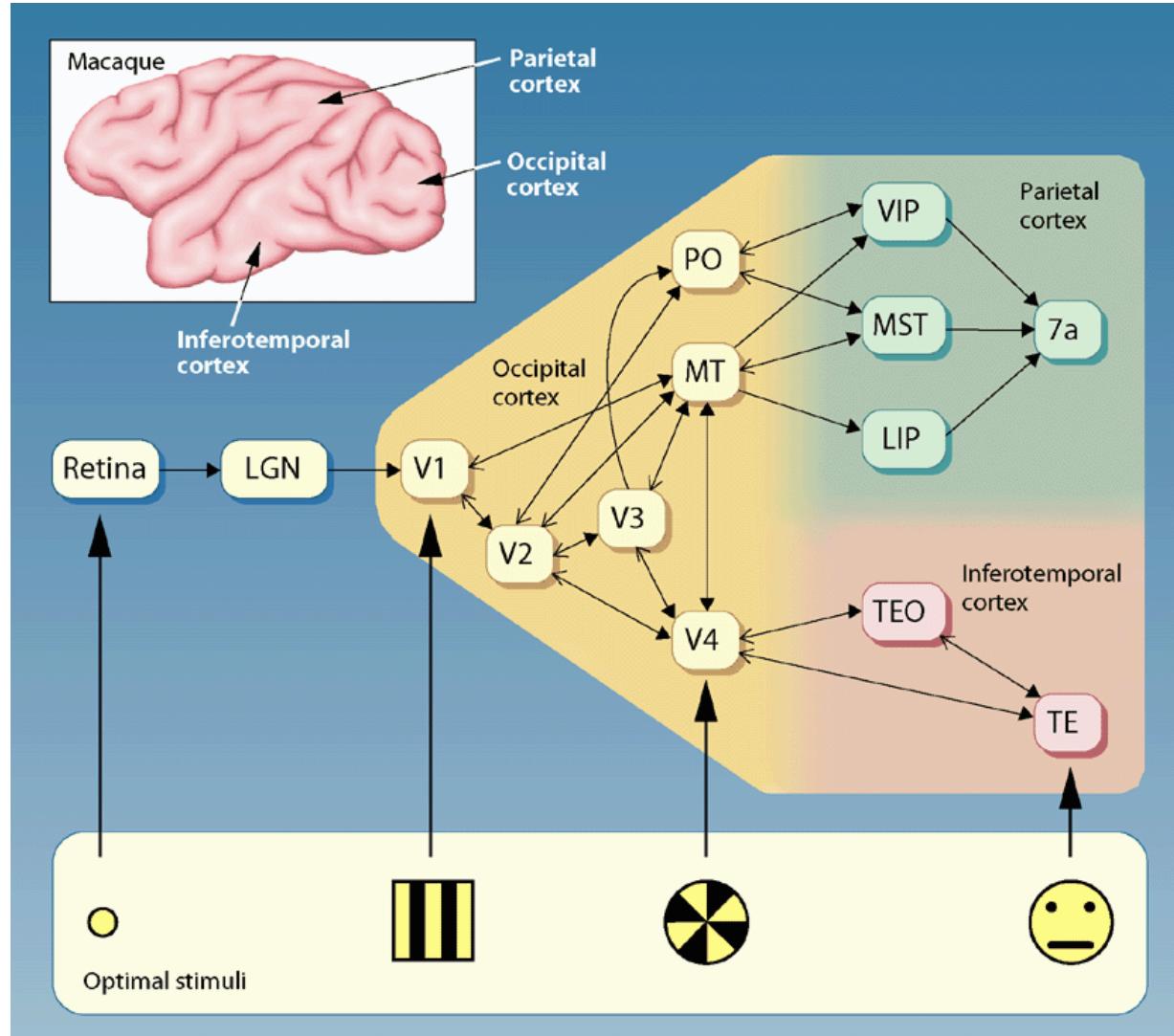
# Visual field



# Receptive field

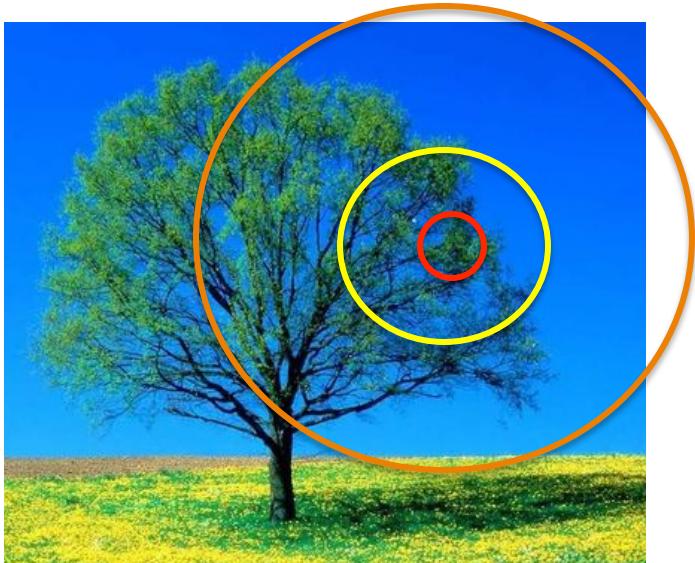
- Portion of the sensory space that affects the signaling of one neuron





Van Essen and DeYoe 1995

# Ventral pathway and receptive fields

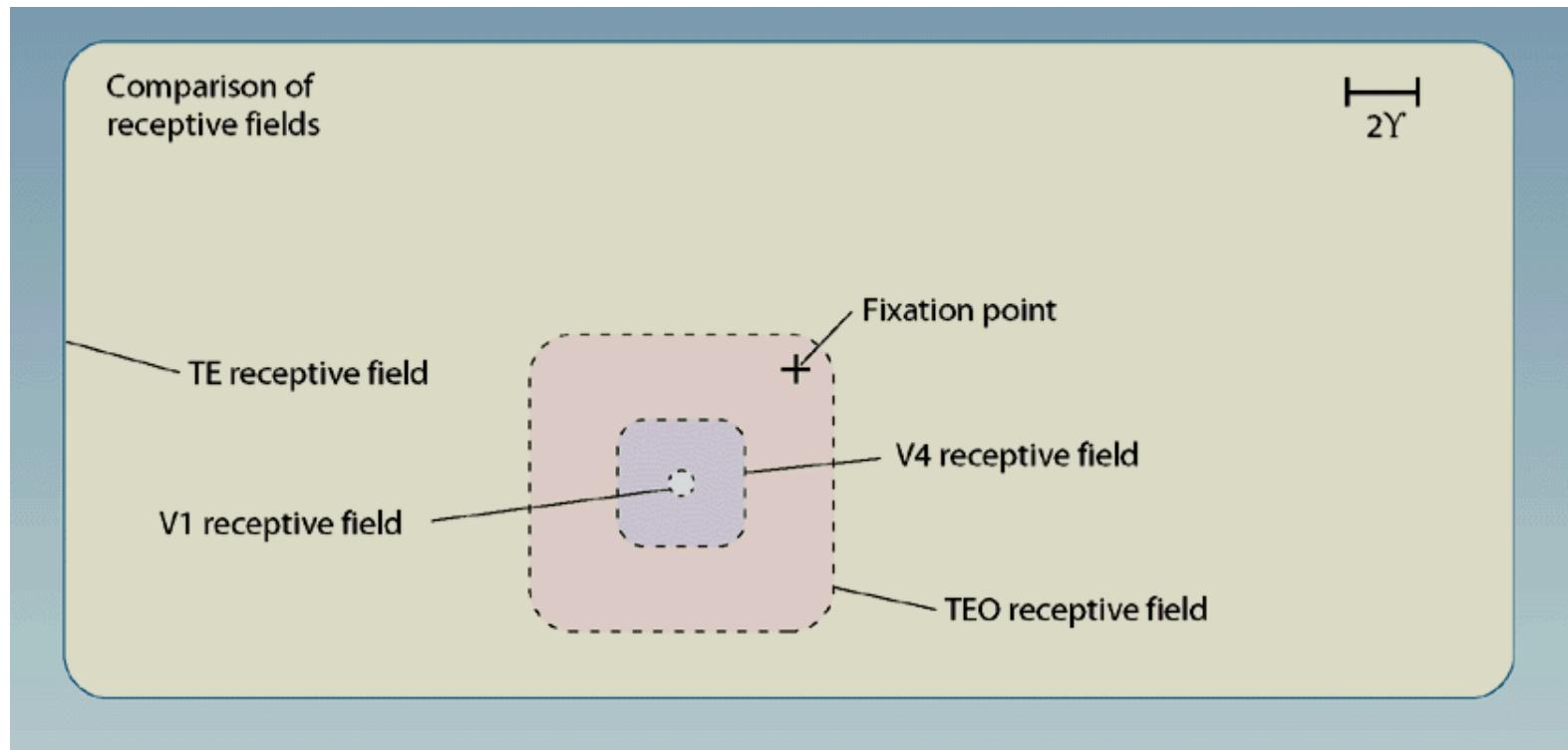


- V1 – small area
- V4 – larger area
- Temporal lobe – very large area

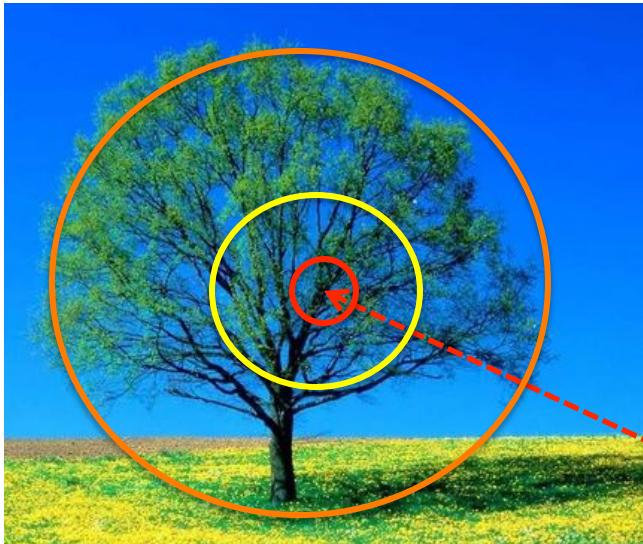
- As you move up the ventral pathway from V1, the larger the receptive field

# Along the Ventral Pathway

- Along ventral stream stages
  - The size of receptive field increases
    - $V1 < V4 < TEO < TE$



# Ventral pathway and complexity



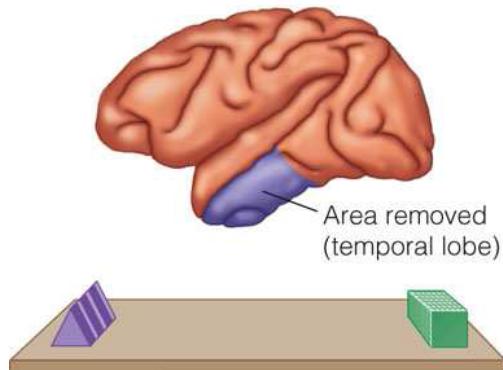
- V1 – lines, basic shapes
- V4 – colors
- Temporal lobe – objects

As you move up the ventral pathway from V1, the more complex the stimulus processing

# Along the Ventral Pathway

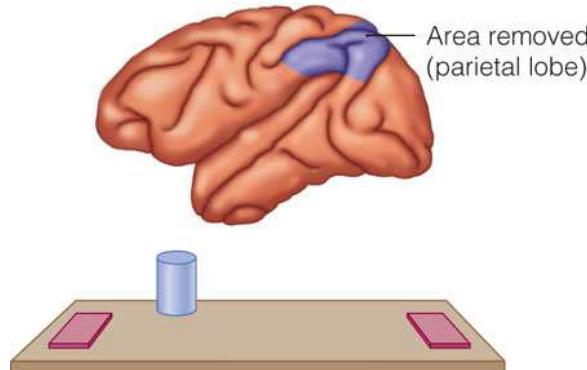
- Along ventral stream stages
  - The size of receptive field increases
    - V1 < V4 < TEO < TE
  - The complexity increases
  - Focuses on stimulus properties, not location
    - ‘What’ pathway

# Classic study by Ungerleider and Mishkin (1982)



(a) Object discrimination

Familiarized with one of the two objects, then choose the other one



(b) Landmark discrimination

Pick the red square next to a cylinder

- Double dissociation between lesion sites (temporal or parietal cortex) and task performance (object or spatial discrimination).
- Established idea of “what” and “where” pathways

# Dorsal pathway: where or how?

- Milner and Goodale's idea:
  - Dorsal pathway – not where, but 'how'
- Dissociation between recognizing and acting on something.

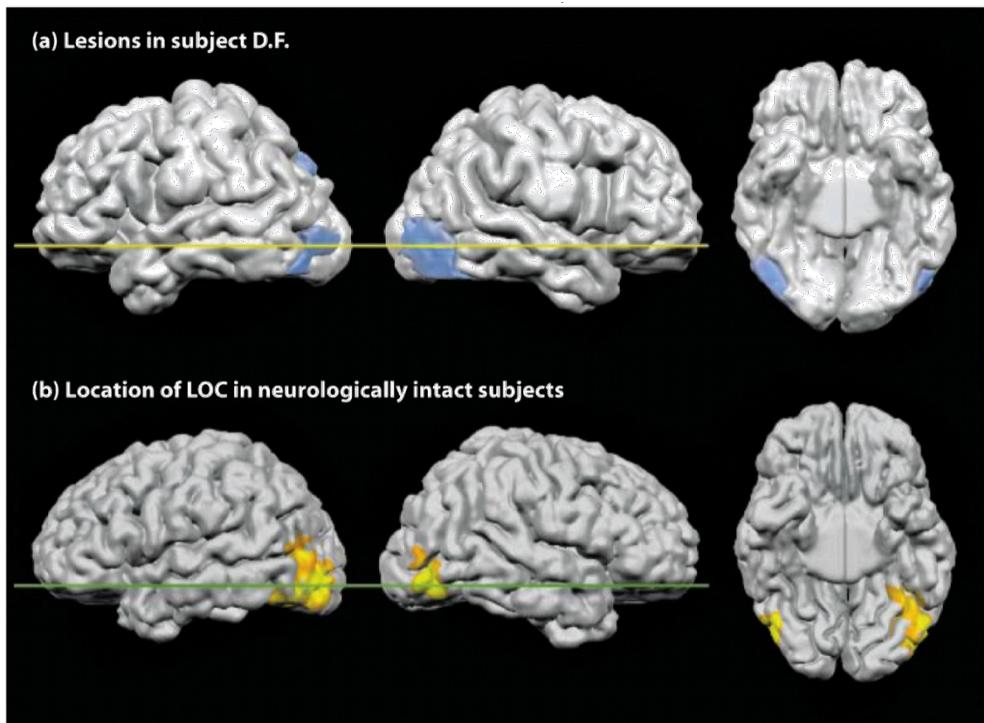
# Dorsal pathway: where or how?

- Patients with optic ataxia can recognize objects, but have difficulty *acting* on them precisely
- Lesions in left intraparietal sulcus (IPS) led to gross misreaching for a target in right peripheral vision
- Normal reaching under foveal vision



Karnath and Perenin, 2005, Cerebral Cortex

# Ventral pathway lesion



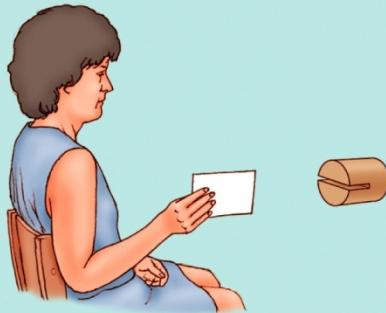
Patient D.F. (studied by Mel Goodale)

Bilateral lesion around the lateral occipital complex (LOC)

- Due to gas leak (carbon monoxide poisoning)

# Ventral pathway lesion (LOC)

Explicit matching task



Action task



Memory task



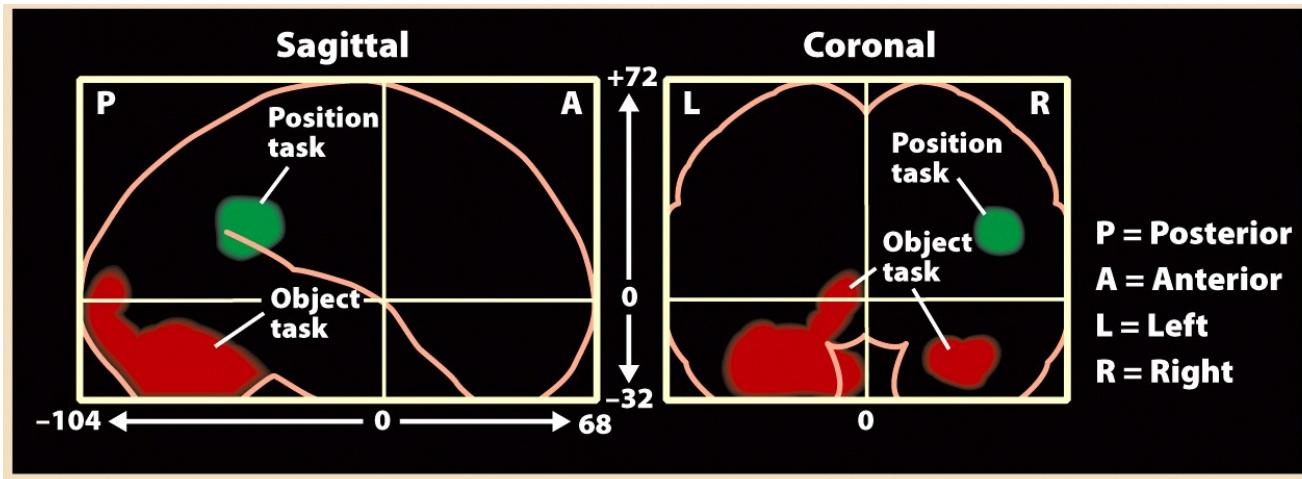
- Cannot recognize objects
  - Can't tell the orientation of the slot
- But knows “*how*” to act on them
  - Slot a letter into it
  - Also intact memory for action

# Another Example of Weakness for Neuropsych

- Temporal lobe lesion also leads to impaired object perception, in contrast to parietal lesion
- LOC lesion also leads to impaired object perception
- Problem with Neuropsych: You don't know if the damaged region is *sufficient* or only *necessary*

# PET/fMRI evidence for what/where distinction

- Object vs. position tasks
  - First see sample
  - Then asked if objects are the same or locations are the same
- Dorsal pathway activation for the position task
- Ventral pathway activation for the object task



Sample stimulus



Object task

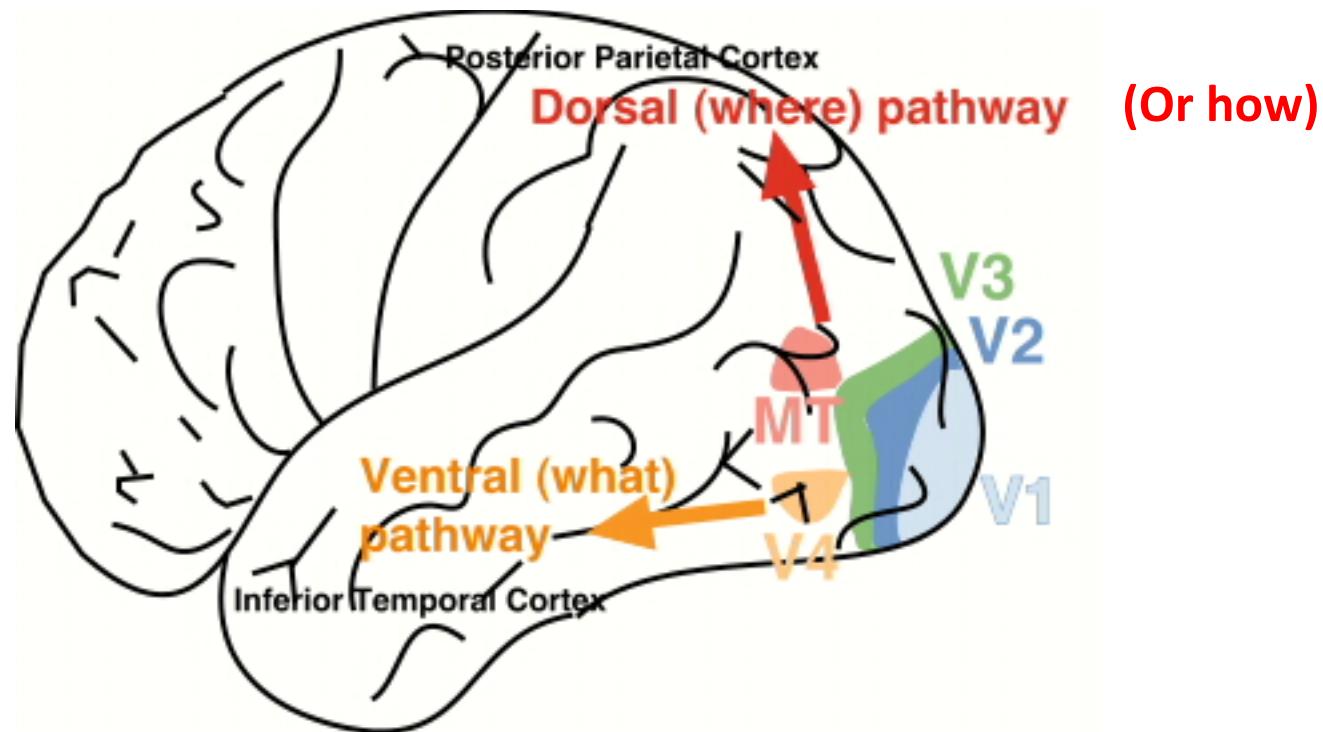


Position task



# Summary

- Ventral pathway – object recognition (what)
- Dorsal pathway – where or how

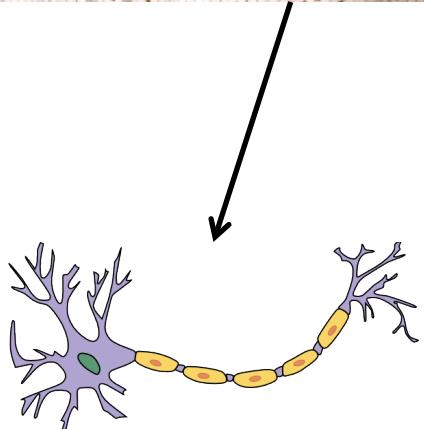
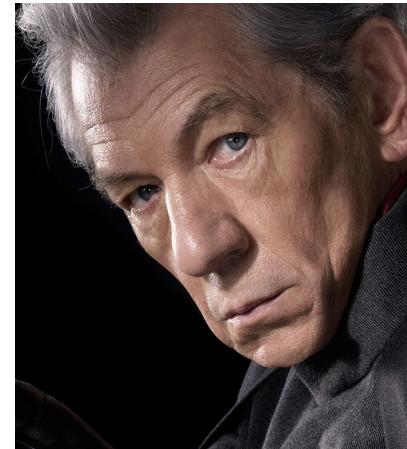
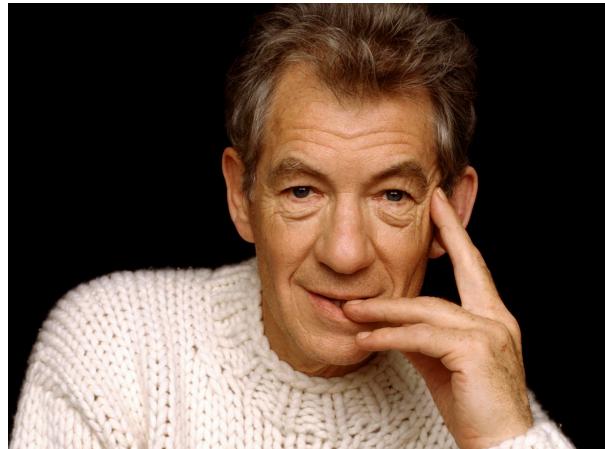




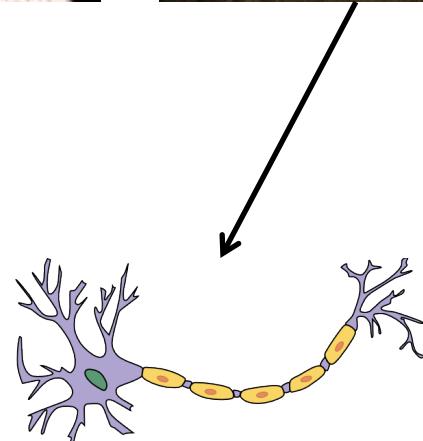
# Object recognition: Grandmother cell

One cell for each angle and size of  
every object we've ever seen

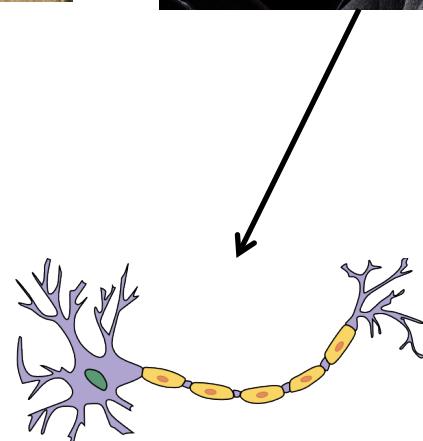
# Grandmother cell



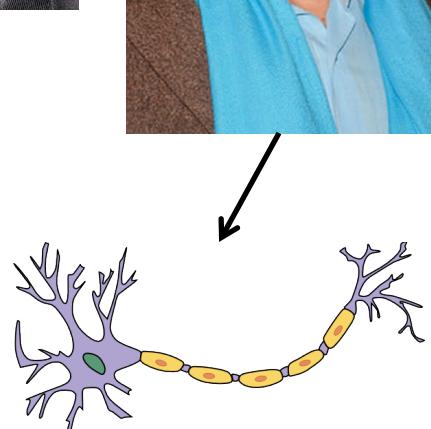
Mckellen with  
hand neuron



Gandolf neuron



Magneto neuron



Mckellen with hat  
neuron

# Problems with Grandmother cell idea

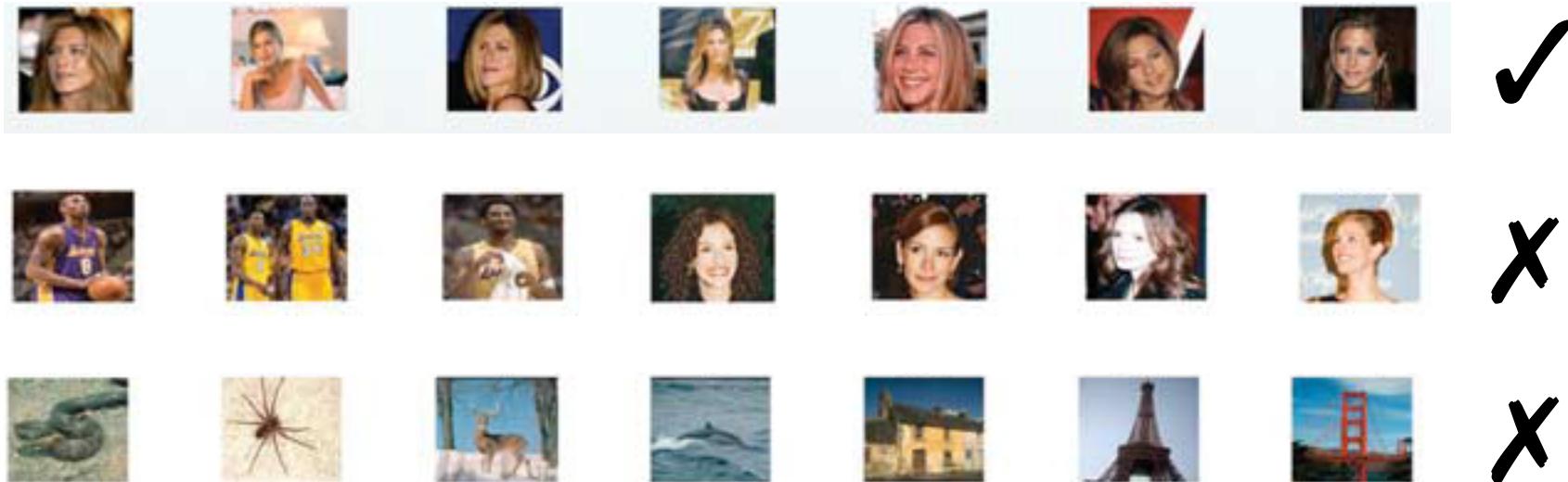
- Grandmother cell (reviewed in Gross, 2002)
  - Jerry Lettin (1969)
- What happens if grandmother cell dies? (Too vulnerable)
- Requires too many cells
- How do we form new “grandmother” cells? (learning of novel object)
- What happens if these change over time?

An alternative

Integrate information across multiple active features, e.g.  
distributed representation.

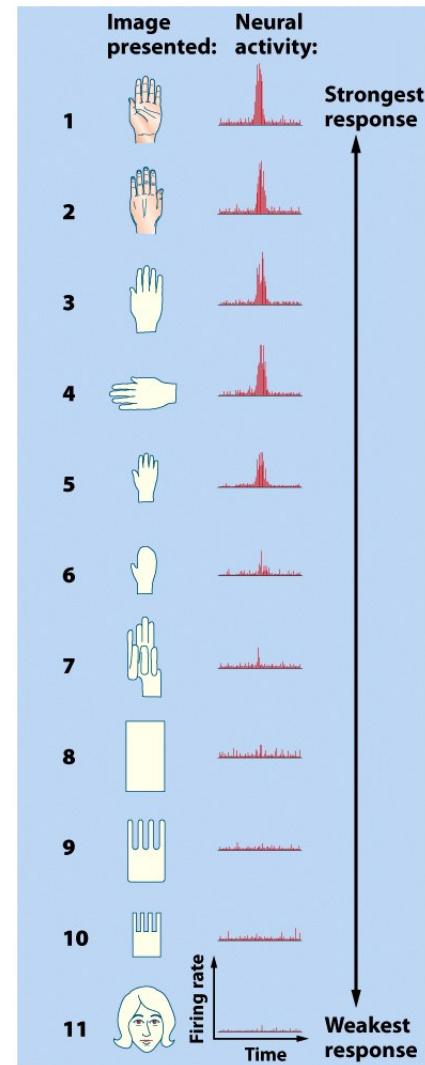
# The Jennifer Aniston Neuron

- Distributed representation
  - Similar to grandmother cell



# Neural Coding

- Shape coding in monkey inferotemporal (IT) cortex to a hand, but not similarly shaped non-hands.
- Jennifer Aniston Cell



# Grandmother cell idea

- Grandmother cell (reviewed in Gross, 2002)
  - Jerry Lettin (1969)
  - gnostic unit (Jerzy Konorski, 1967)
- Jerry Lettin's talk at MIT in 1969 That an imaginary Russian neurosurgeon Akaki Akakhievitch "located some 18,000 neurons that responded uniquely only to a mother, however displayed, whether animate or stuffed, seen from before or behind, upside down or on a diagonal, or offered by caricature, photograph, or abstraction".
  - From Gross, C. G. (2002). *Genealogy of the "grandmother cell"*. *The Neuroscientist*

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Because this patient wanted to forget his overbearing, impossible mother, Akakhievitch, one by one, ablated all the neurons related to the concept of his mother. When the patient woke up from anesthesia, he had lost all notion of his mother. All memories of her, good and bad, were gone.

# Ensemble (population) coding

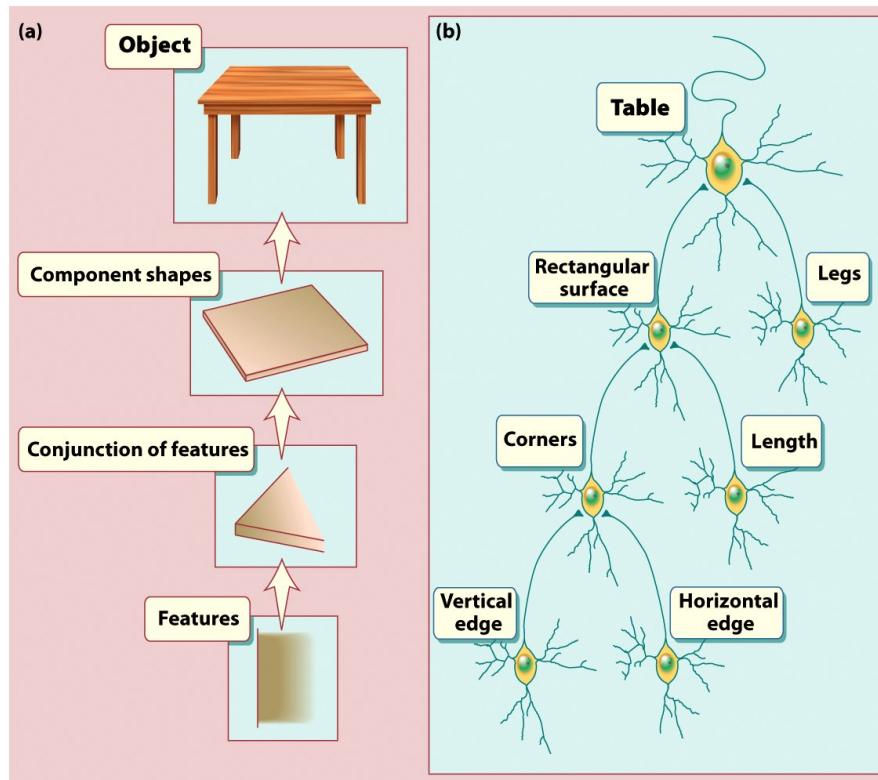


Many neurons code parts of object together

Individual cells have continuous coding for a certain feature

Supports *flexibility and specificity*

# Highest-level integrated representations

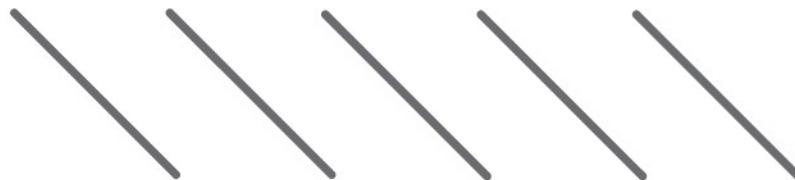


- Individual features lead to highest representation.

## Basic elements and the different objects they can form

### Low-level starting components

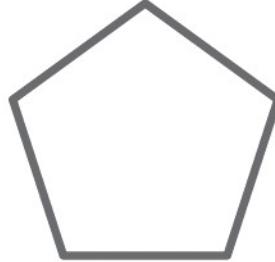
**Five lines:**



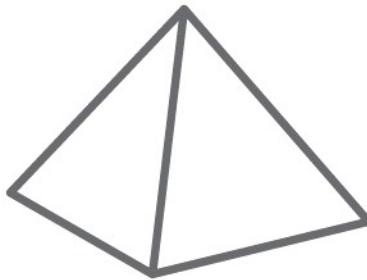
**a**

**High-level percepts**

**Pentagon:**

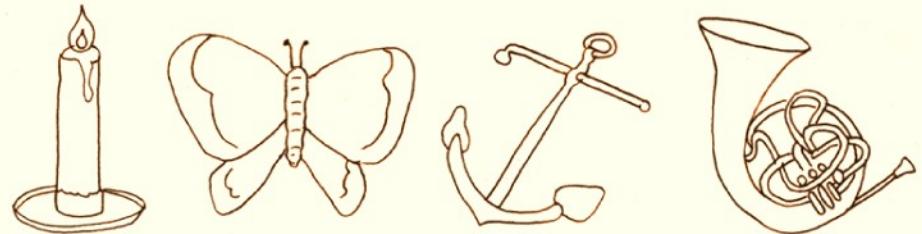
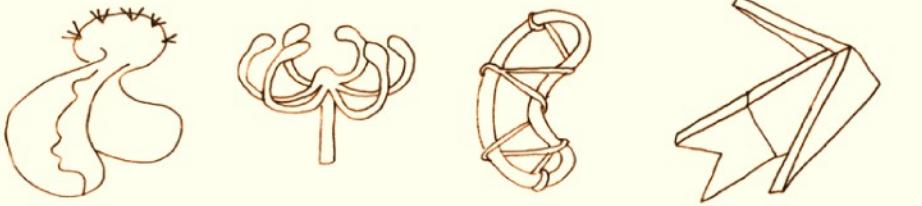
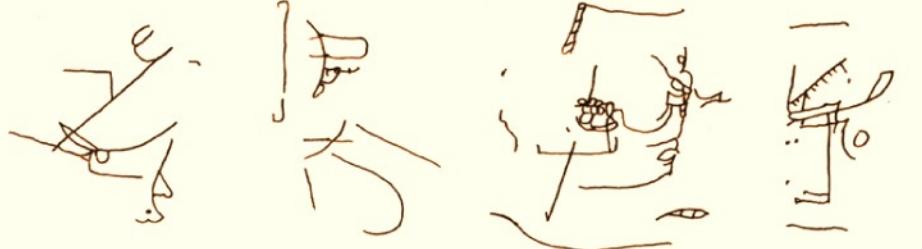


**Pyramid**



**b**

## Component analysis of object recognition

	Sample stimuli	Feature extraction	Shape description	Memory matching
Familiar		✓	✓	✓
Novel		✓	✓	
Scrambled		✓		

See activation in ventral pathway for familiar and novel, but not scrambled

- fMRI

# Visual Agnosia

- Failure to *recognize* objects in visual domain. Recognition can be made with other modalities such as audition or smell.
- Not a deficit in primary sensory processing of visual information (i.e. can see, but can't verbally recognize).
  - “What it looks like” but not “what it is”
- Can identify named objects, but cannot generate name to seen object (recognition)
- Frequently with bilateral occipitotemporal damage
  - Perhaps some hemispheric differences for different sub-types

# Agnosia versus Memory Loss

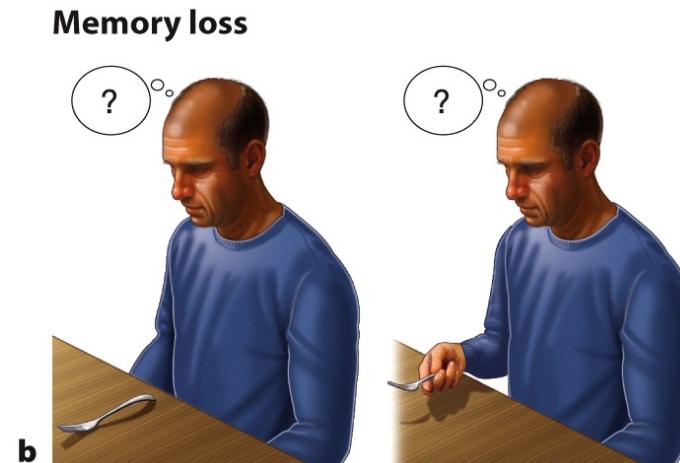
Visual agnosia:

- Unable to recognize a fork by vision alone
- Immediately recognizes it when she picks it up.



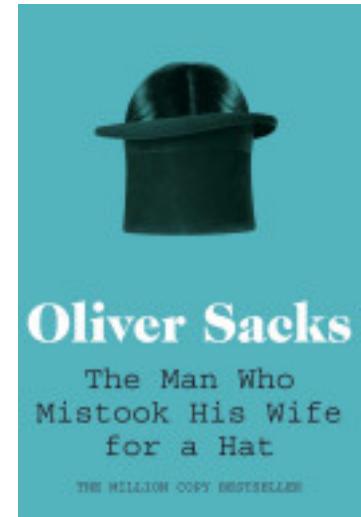
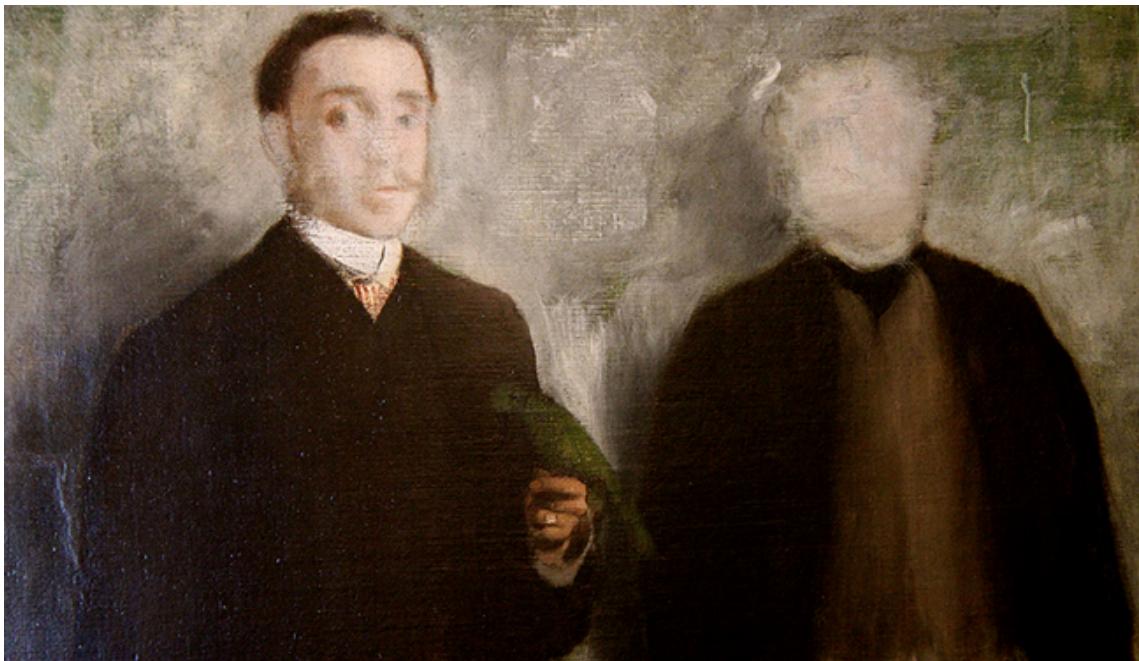
Memory loss:

- The patient with a memory disorder is unable to recognize the fork even when he picks it up.



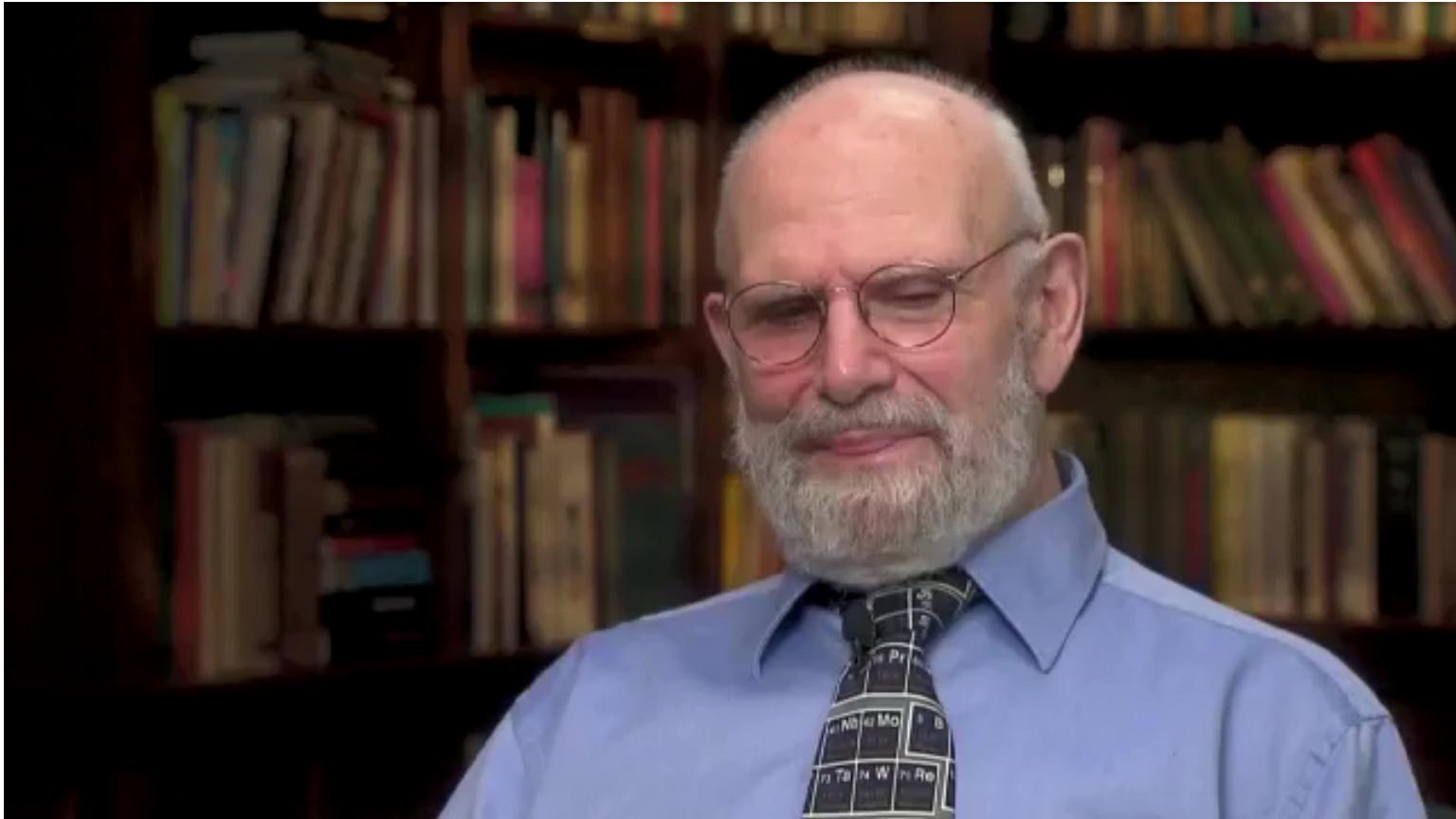
# Prosopagnosia (face blindness)

- Inability to identify or recognize faces, but no deficit in object recognition, in ~8% of population
- Can occur as result of bilateral temporal lobe damage but also congenital
- Can recognize people based on other traits such as voice, gait or other body features (Dr. P.'s brother's square jaw and big teeth)
- Can often see emotions from facial expressions



"Dr. P."

# Living with Face Blindness



CNN's Sanjay Gupta speaking with Dr. Oliver Sacks,  
DR. Sacks is a famed neurologist with face blindness.

# Social consequences

"I just see the general shape," she said, "and I see the hair." ...

When Kari meets somebody, she notes their location. If she's at school, for example, it's probably a classmate. Then she looks for other clues: hairstyle, mannerisms, body structure, whether the person wears glasses or jewellery. She'll listen carefully to voices and note how people move. In the winter, she'll memorize people's coats.

<http://www.theglobeandmail.com/servlet/story/RTGAM.20080110.wlfaceblind10/BNStory/specialScienceandHealth/home>

"So many people hate me because they think I'm disrespecting them, ... But it's a mystery to me, man. I can't grasp a face, ..." --- Brad Pitt

<http://www.cnn.com/2013/05/23/showbiz/celebrity-news-gossip/brad-pitt-esquire-face-blindness/>

- Sounds like faces are special, but what is missing?
- This is a single dissociation. Is there anyone that can recognize faces but not objects?

# Can face and object recognition be doubly dissociated?

- Object agnosia with preserved face processing
- CK cannot identify objects but can identify faces



# Are faces special?



# Phenomenologically, yes



# Are faces special?

1. Prosopagnosiacs fail to recognize people but can recognize other things.
  - Suggests faces may be special
2. Functional independence: can a double dissociation be found?
3. Anatomical separation: distinct neural mechanisms (or regions) from objects?
4. Are faces and objects processed differently?

# Can face and object recognition be doubly dissociated?

- Object agnosia with preserved face processing
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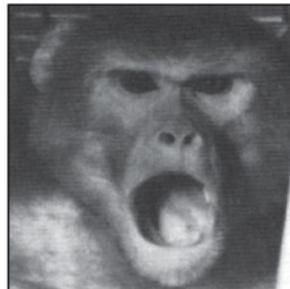
# Superior temporal sulcus in monkeys shows responses to faces but not objects



A



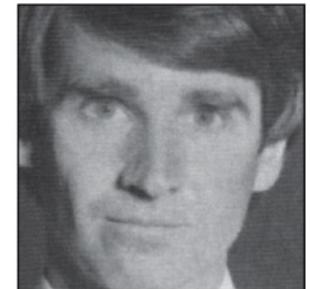
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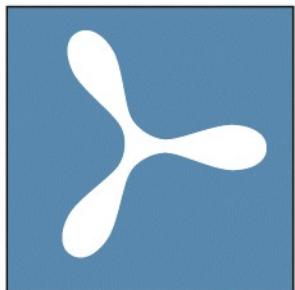
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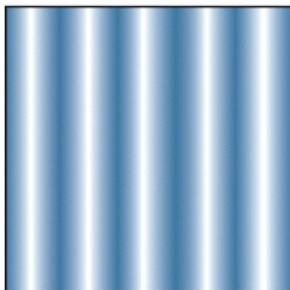
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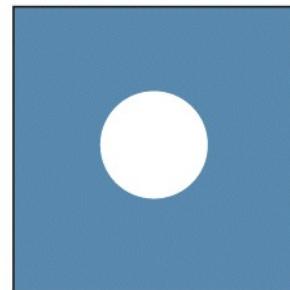
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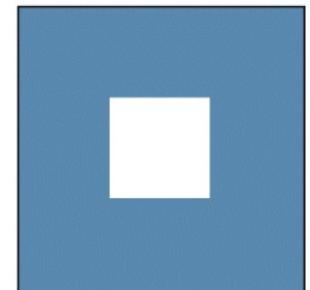
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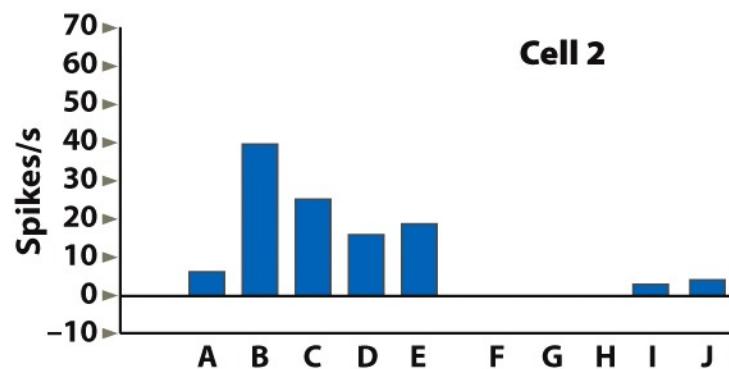
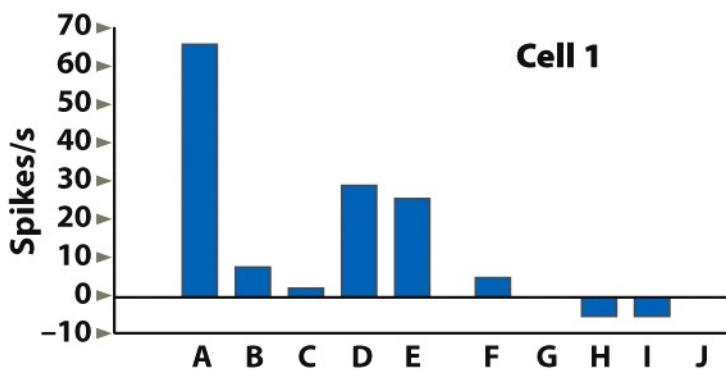
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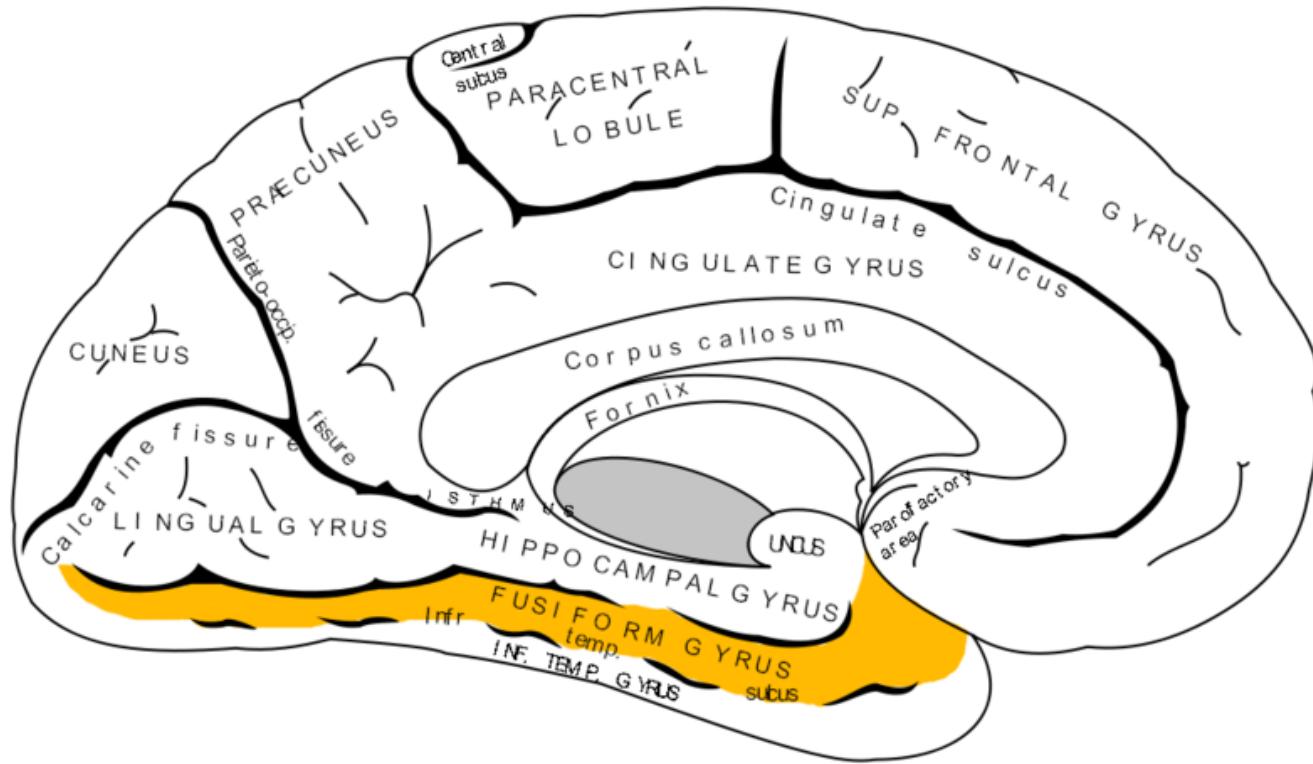
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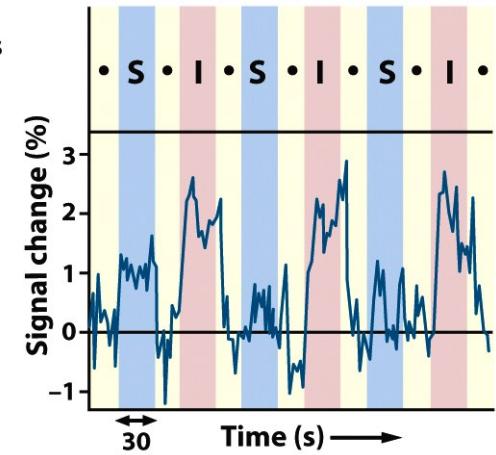
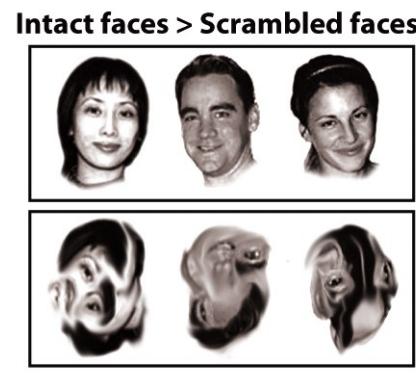
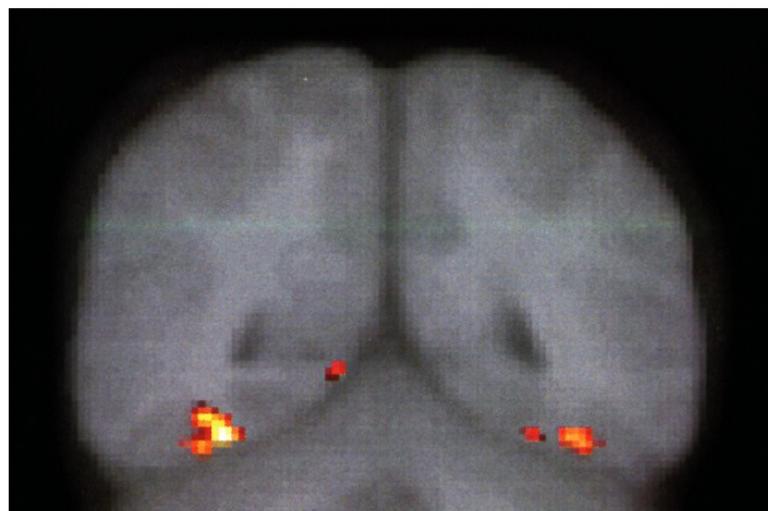
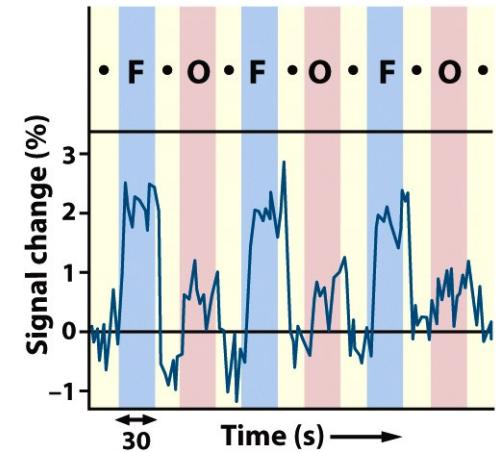
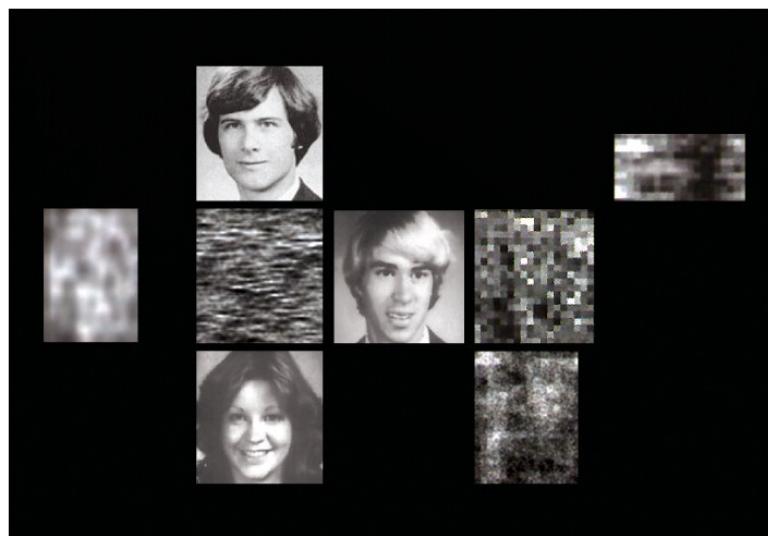


Superior temporal sulcus in monkeys =  
*Fusiform gyrus* in humans



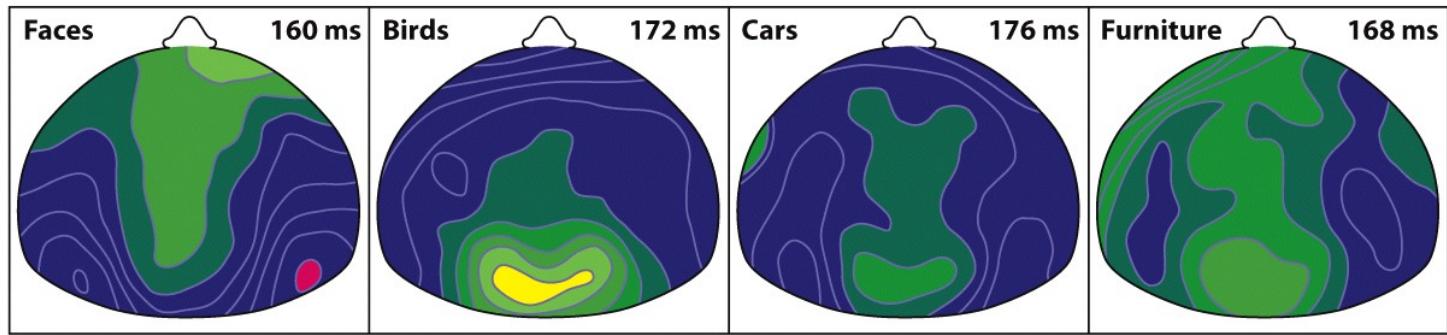
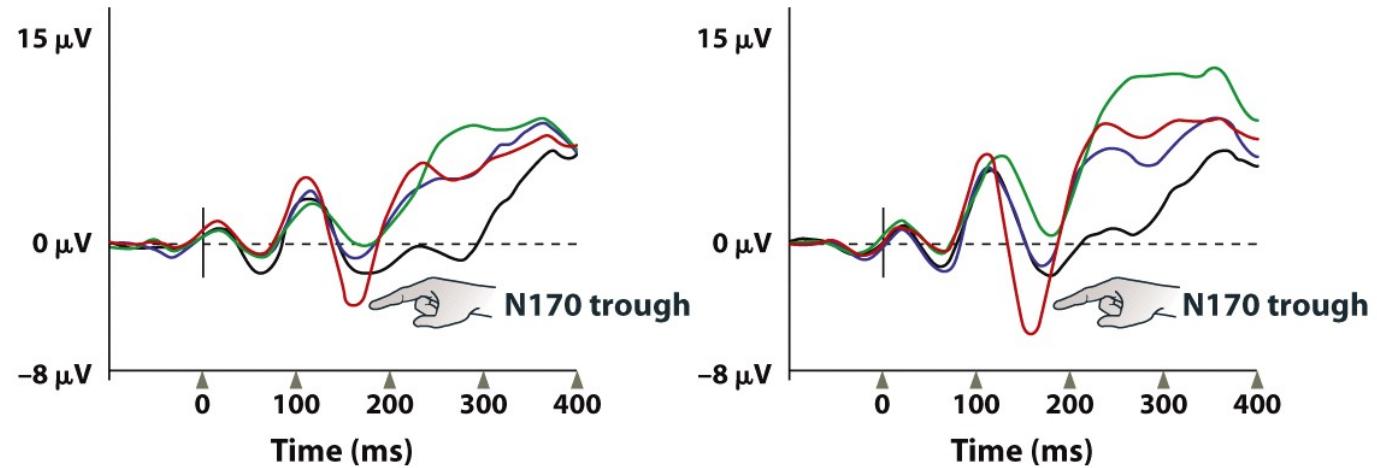
Also called fusiform face area (FFA)

# Fusiform Gyrus

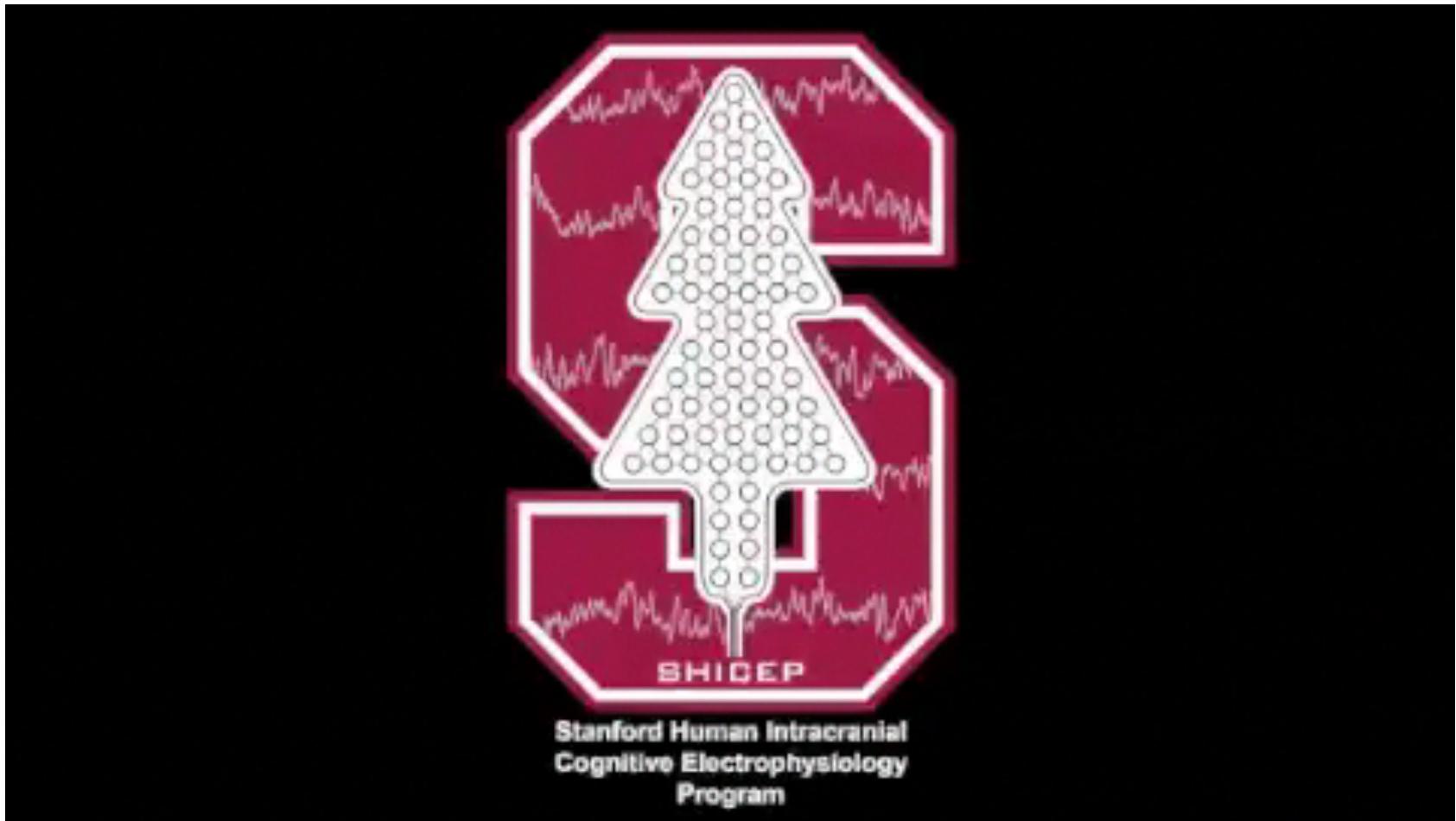


Why using scrambled face?

# Face specific ERP (N170)



# Changing Faces: Stimulating the Brain Morphs People's Faces



Parvizi et al. (2012). Electrical Stimulation of Human Fusiform Face-Selective Regions Distorts Face Perception. *Journal of Neuroscience*

# Face inversion effect

- Who is this person?  
Anything looks weird in the picture?
- Difficult recognition when faces are viewed upside down.
- Difficult to see severe distortions in the upper image created by inversion of the eyes and mouth, which is immediately apparent when the image is viewed right side up.



# Sequential presentations of two faces

Are the top halves the same?



# Composite Face Effect (CFE)

Are the top halves the same?



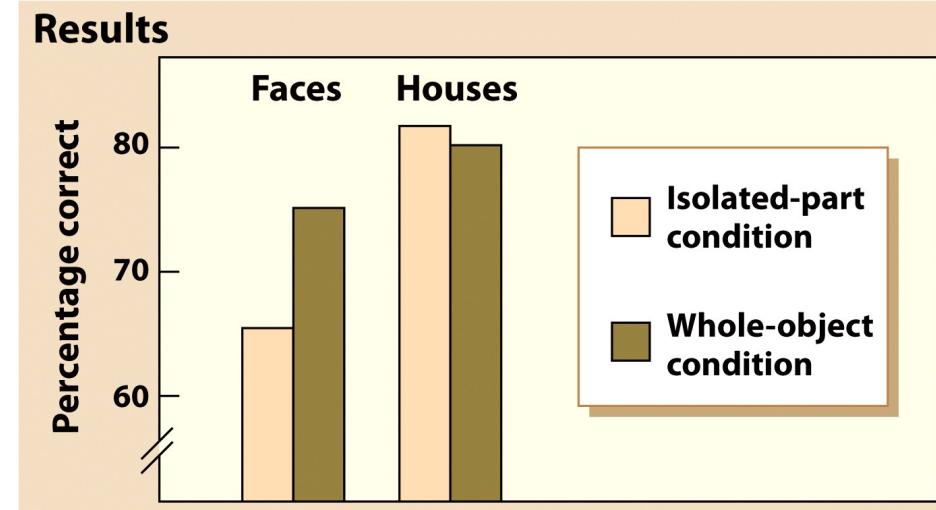
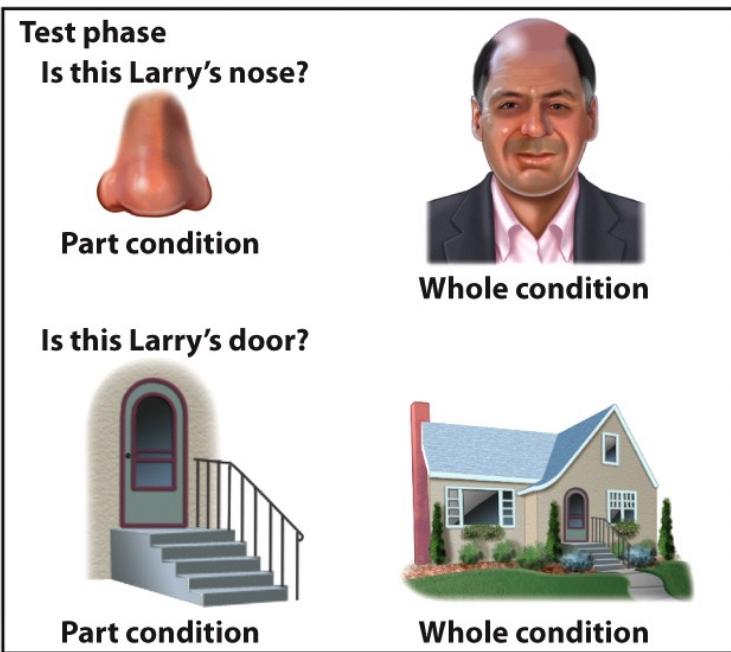
Worse performance when top and bottom halves are aligned  
(Le Grand et al., 2004)

# How are faces processed differently?

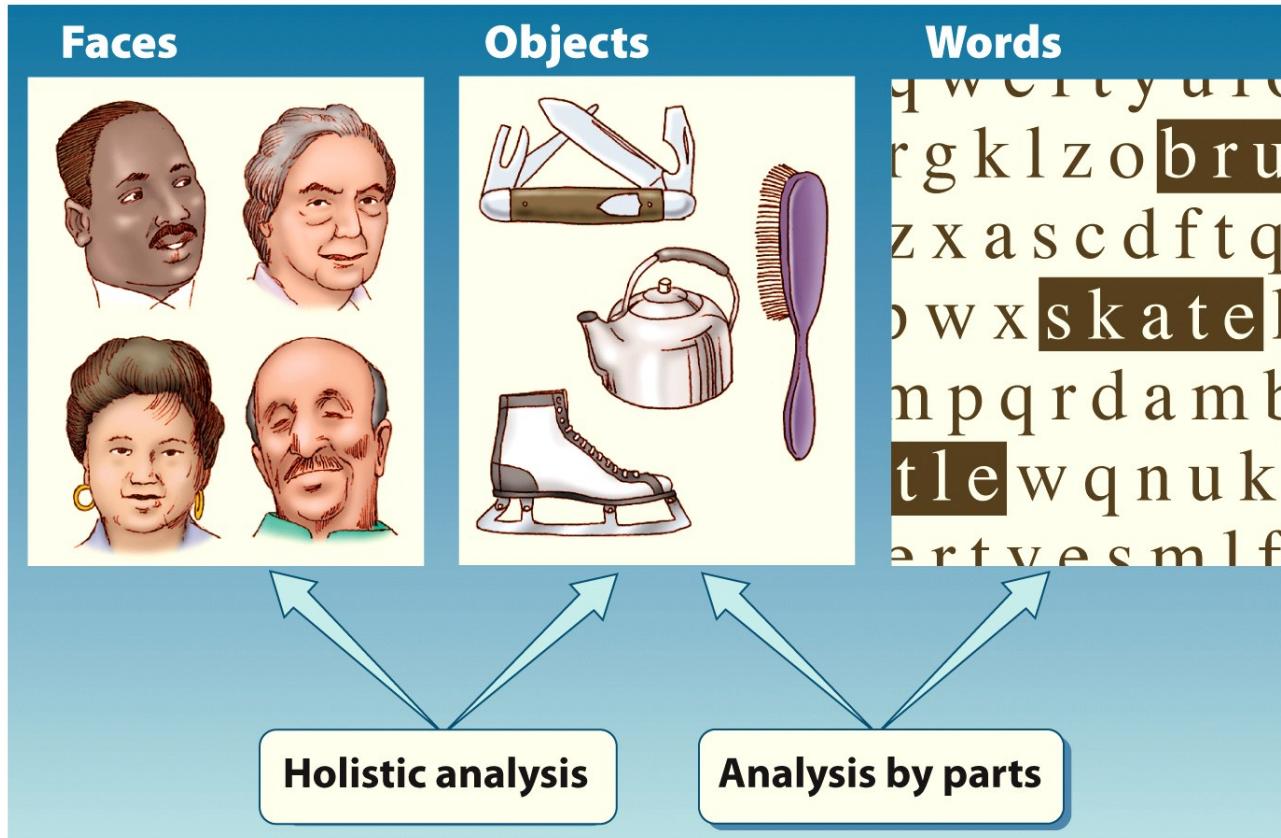
- Both the face inversion effect and Composite Face Effect suggest that face recognition is critically dependent on a *holistic processing* of facial components
- Wholes vs. parts
  - Faces, objects, and words use partially-different processes along wholistic-to-part based continuum

# In face recognition Seeing the forest and missing the trees

Facial features are poorly recognized in isolation



# Farah's two-process model for object recognition

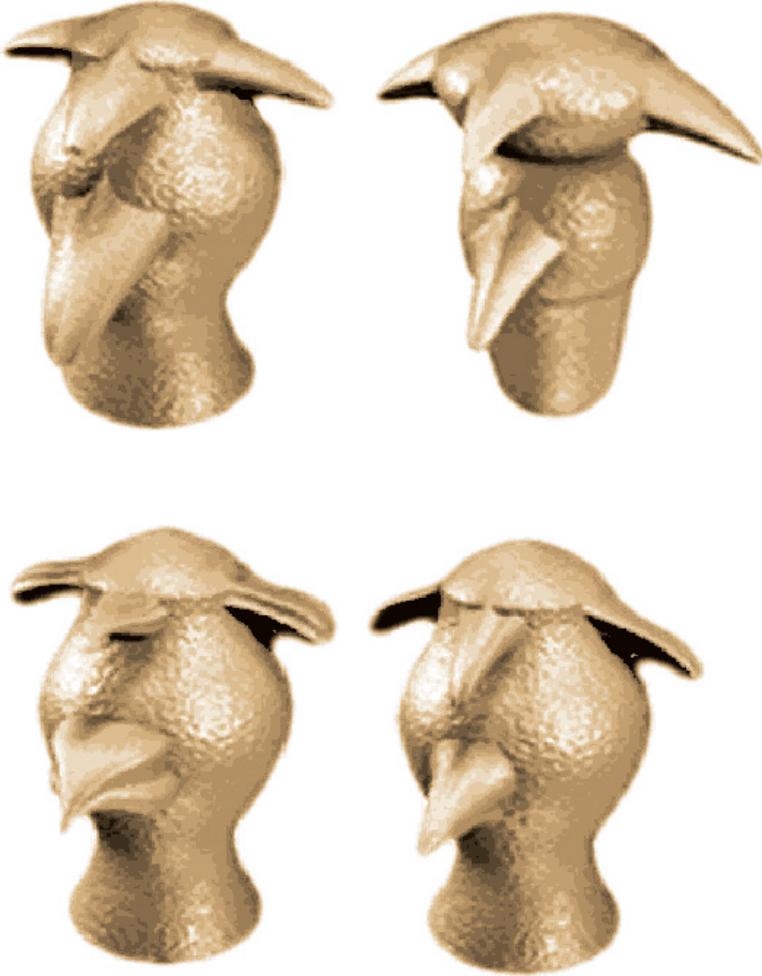


- Holistic vs. parts
  - Faces only by holistic
  - Objects by both
  - Words by parts only

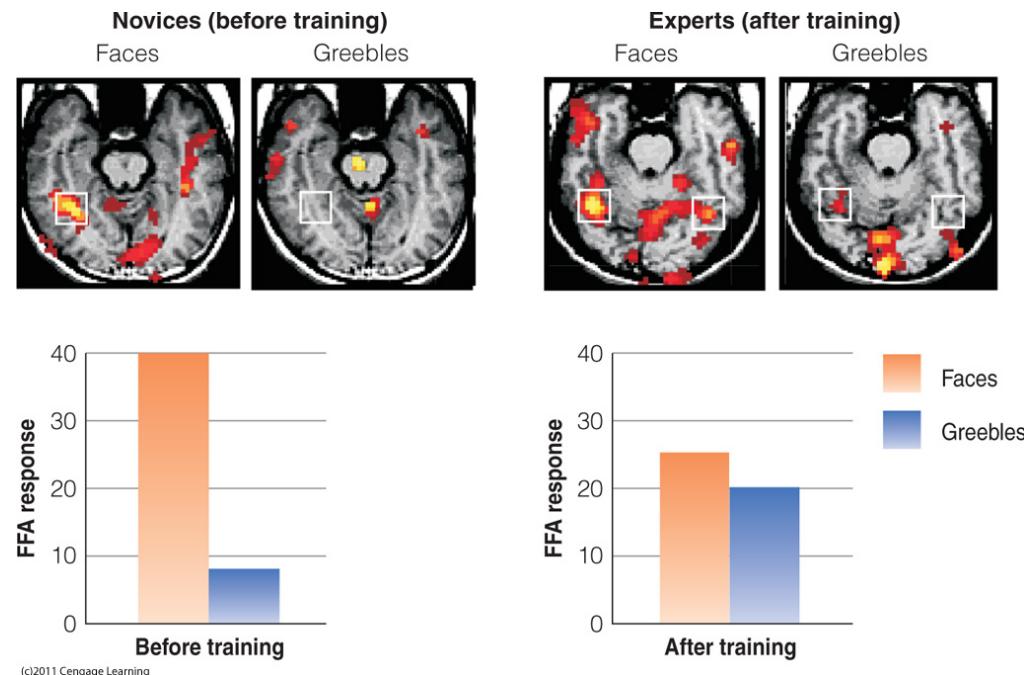
# Is face recognition just specialized object recognition?

- Expertise
  - Are faces our most expert domain of recognition?
  - Similar to perceptual filling in of vertical bars
    - Experts at perceiving vertical lines

# Expertise, yes!



Greeble stimuli used by Gauthier. Participants were trained to name each different Greeble.



**Magnitude of brain responses to faces and Greebles (a) before and (b) after Greeble training. The colored areas in the brain records indicate brain activity. The FFA is located within the white squares.**

**Training modulates FFA activities**

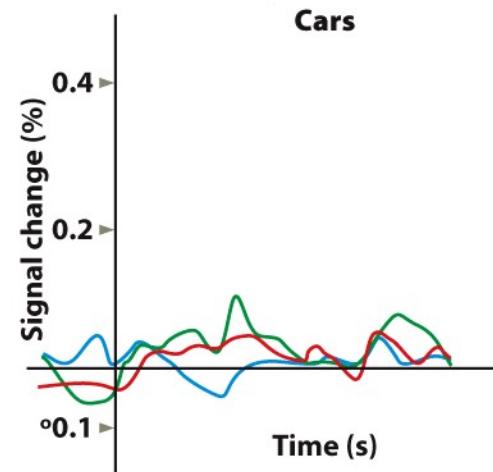
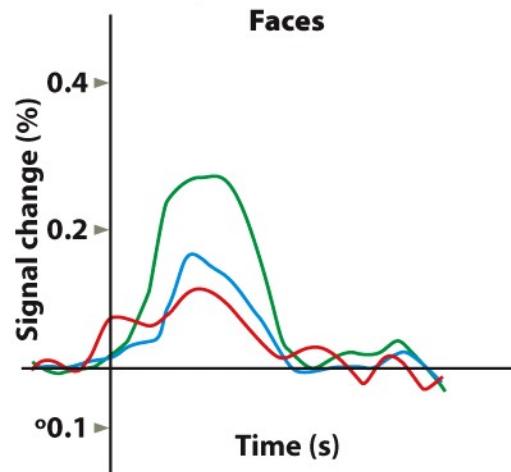
# Expertise, NO!

FFA activity is related to stimulus class and not expertise

Identify the specific car/face

Identify the category (car or face)

Wrong response



A group of car aficionados viewed pictures of faces and cars

# Are faces special?

1. Prosopagnosiacs fail to recognize people but can recognize other things.
  - Suggests faces may be special
2. Functional independence: double dissociation between object and face rec.
3. Anatomical separation: fusiform face area
  - May also be an expertise area
4. Are faces and objects processed differently?
  - Holistic versus analysing parts

# Essentials

- Distinction between what and where/how pathways and experimental support.
- Agnosias, what they say about perception/object recognition.
- Grandmother cell hypothesis vs. ensemble coding.
- Face recognition may be special
  - Dedicated neural substrate,
  - Holistic processing: face inversion, CFE, part-whole
  - But wait, maybe expertise in general
    - Faces vs. expertise.